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ECOLOGY OF DORCHESTER BAY AREA PERTAINING
TO URBAN DEVELOPMENT
OF
THOMPSON ISLAND

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P.

GEOLOGY OF DORCHESTER BAY AREA PERTAINING
TO URBAN DEVELOPMENT
OF
THOMPSON ISLAND

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Boston Harbor Island Study
July 31, 1968



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I BEDROCK PROPERTIES

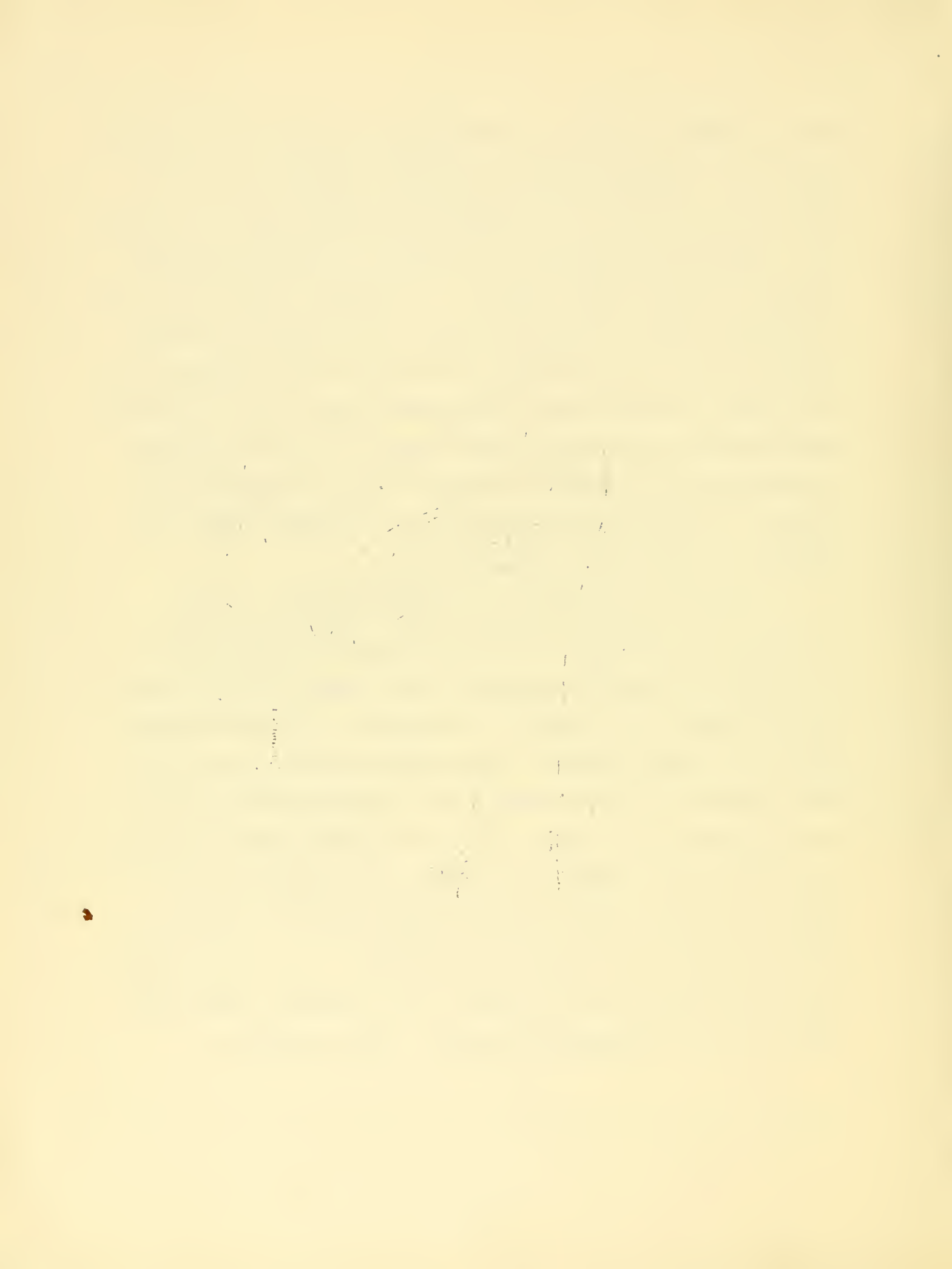
Most of Boston Harbor is underlain by a dark, fine-grained, silicious rock known as Cambridge Argillite, Cambridge Slate, or Cambridge Siltstone, depending upon which author one reads. In some areas of the harbor, this rock is covered by Roxbury Conglomerate or Squantum Tillite. (See figure 1.) The Squantum Tillite is a softer rock, being composed of poorly sorted glacial deposits in a clay matrix. The Roxbury Conglomerate is composed of shale, slate, argillite, sandstone, quartzite, and various volcanic materials. In general the conglomerate is overlain by the tillite, which is in turn overlain by the argillite. The lower members of the sequence are exposed only in areas where the upper members have been eroded away.

The depth to the bedrock surface is very important in determining the cost and nature of building foundations and utilities placement. If the bedrock is shallow, buildings may be supported on piles, allowing the use of relatively cheap, locally abundant clay for the land fill. If, however, the bedrock is buried under thick layers of unconsolidated sediments, the cost of placing piles becomes prohibitively expensive, and one is forced to consider floating foundations placed in a non-compressible granular fill such as clean sand or gravel.

Unfortunately, there is very little information available concerning depth to bedrock within the harbor area. Upson and Spencer (1964) suggest the existence of several Pleistocene

river valleys, or buried bedrock valleys, under the Dorchester Bay area. This could place the bedrock surface as deep as 250 feet below sea level in parts of Dorchester Bay, yet there are bedrock outcroppings at the surface in parts of Squantum (Squaw Rocks and Chapel Rocks). Dr. Clifford Kaye of the U. S. Geological Survey, noted authority on the geology of Boston, explained that he personally does not place much confidence in the buried bedrock valleys, adding that there are few reliable measurements in these areas (see figure 2.), and the bedrock contours are too irregular to predict the existence of such valleys. He did add, however, that the bedrock surface may indeed be quite deep in Dorchester Bay.

There are no borings on Thompson Island or in the immediate area, though there are some boring records for the Old Harbor area and the Neponset River estuary (Boston Society of Civil Engineers, 1961) and in the area of the old Squantum Naval Air Station (Jackson and Moreland, 1955). While most of the borings in the Old Harbor and the Neponset areas did not reach bedrock, the borings near the Naval Air Station indicate some sort of rock surface at elevation -80 (approx.) feet. Upson and Spencer (1964) found a maximum depth to bedrock of 243 feet along the shore of the Old Harbor. It is hoped that this information can be extended to the Thompson Island site with the aid of geophysical surveys. (See appendix.)



II SEDIMENT DEPOSITS IN BOSTON HARBOR

On a large scale, most of Boston Harbor contains a relatively thick layer of soft clay referred to as the Boston Blue Clay. This blue clay is a still water deposit whose thickness ranges from about 2 feet to over 200 feet. It is often separated from bedrock by thin layers of sand or gravel, and in some areas there are thin beds of sand and silt within the clay.

The upper layer of the blue clay has been oxidized to form a generally firmer yellowish clay. This oxidation is believed to have taken place at a time when much of the harbor bottom was above sea level. There has since been a general subsidence of the entire Boston Basin area, with a subsequent rise in sea level. (Marmer, 1944)

Above this yellow clay lies a thin (5 feet to 10 feet) layer of silt covered by mud. Much of this mud is of the black, carbonaceous variety and is of great concern to us at present. This mud often contains trapped gases, making it very soft and compressable. Also, this gas makes the mud impervious to certain methods of seismic survey, notably, the new E. G. & G. electronic pinger. The normal thickness of these mud deposits is less than 15 feet. However, in the Dorchester Bay area these mud deposits average about 20 feet in thickness (Barlow, 1966), and the thickest mud beds (40 feet) in the inner harbor are found in the Neponset River Channel, just west of Thompson Island.

Thompson Island itself is of glacial origin. The northern

half of the island - that occupied by Thompson Academy - is a drumlin resting in glacial till. The southern half appears to be a gravel outwash which extends a good distance from the island as a buried gravel bed.

The surficial deposits surrounding Thompson Island appear to be mostly mud with some sand and gravel mixed. There are many large pebbles and cobbles on most of the beach surrounding the island, and there are extensive clam beds on the southern and western beaches. Again, there is virtually no information cataloged on the Thompson Island site except what can be obtained visually. It is hoped that the seismic survey described in the appendix will be carried out in order to provided the much needed information. (See figures 3 and 4)

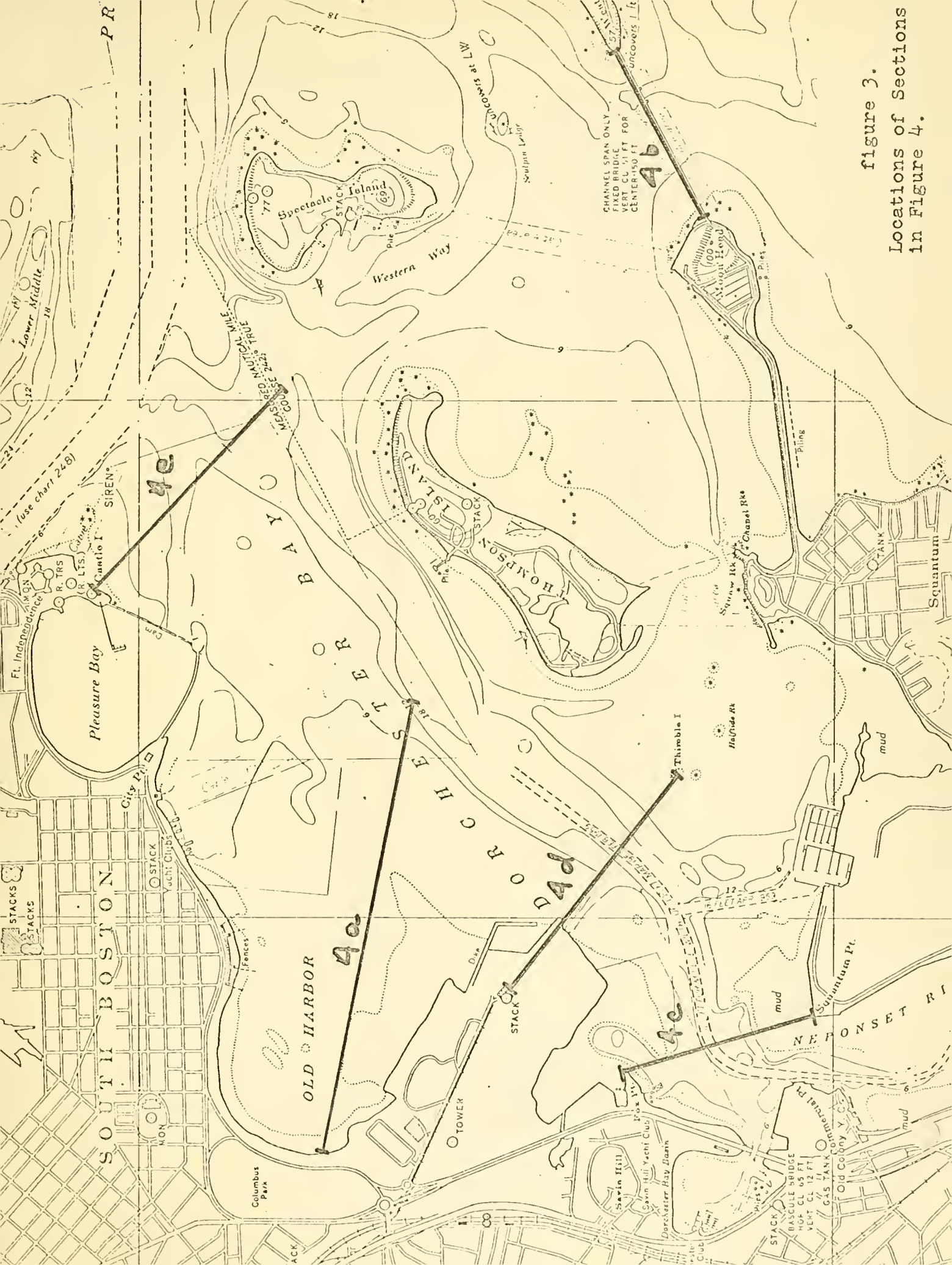


figure 3.

Locations of Sections
in Figure 4.

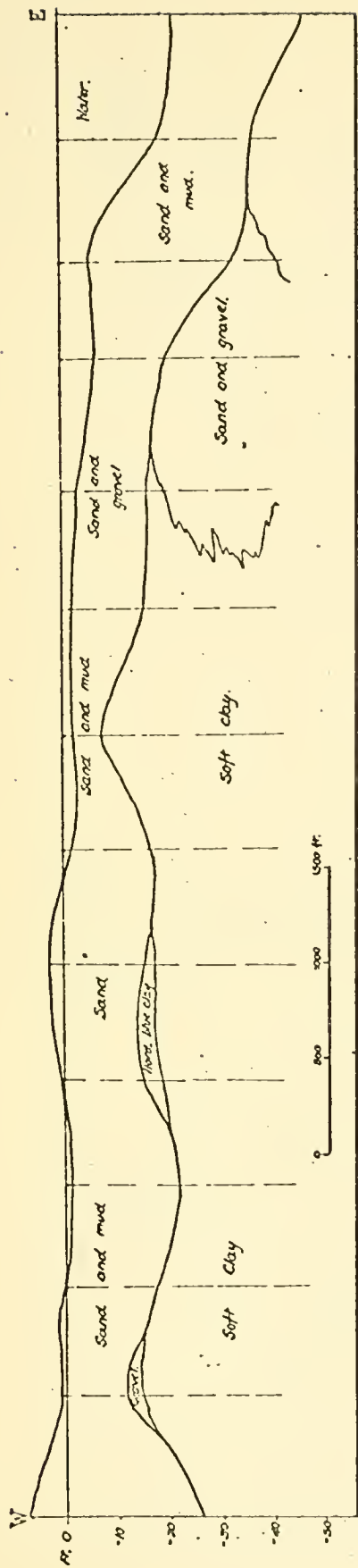


figure 4a. Section in Dorchester Bay from Old Harbor towards Thompson Island. (after Phipps, 1964)

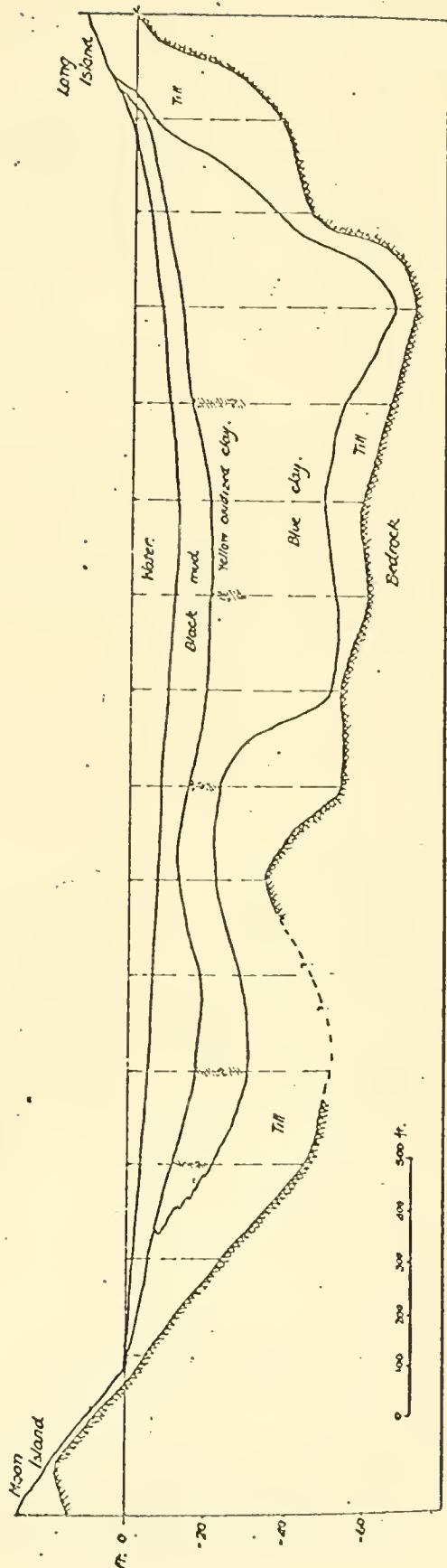


figure 4b. Section along Causeway from Moon Island to Long Island. (after Phipps, 1964)

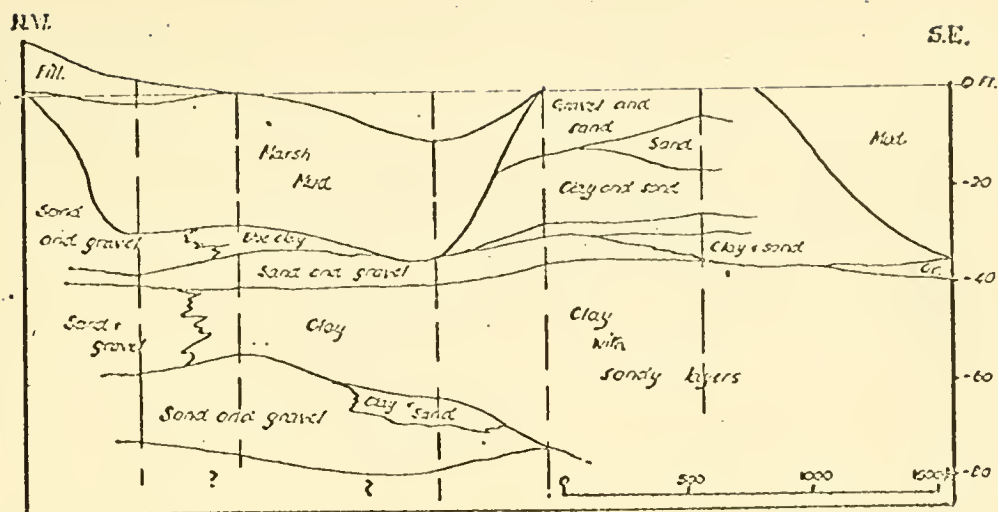


figure 4c. Section through Fox Point to Squantum Point.
(after Phipps, 1964).

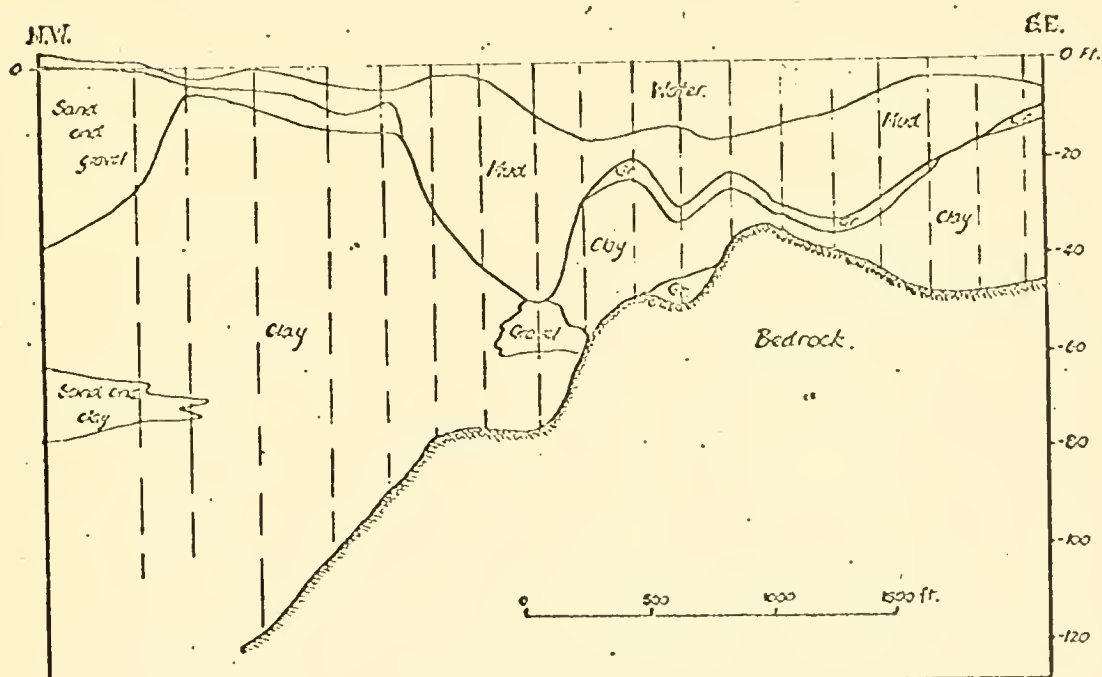


figure 4d. Section in Dorchester Bay; Mt Vernon to Thimble Is.
(after Phipps, 1964)

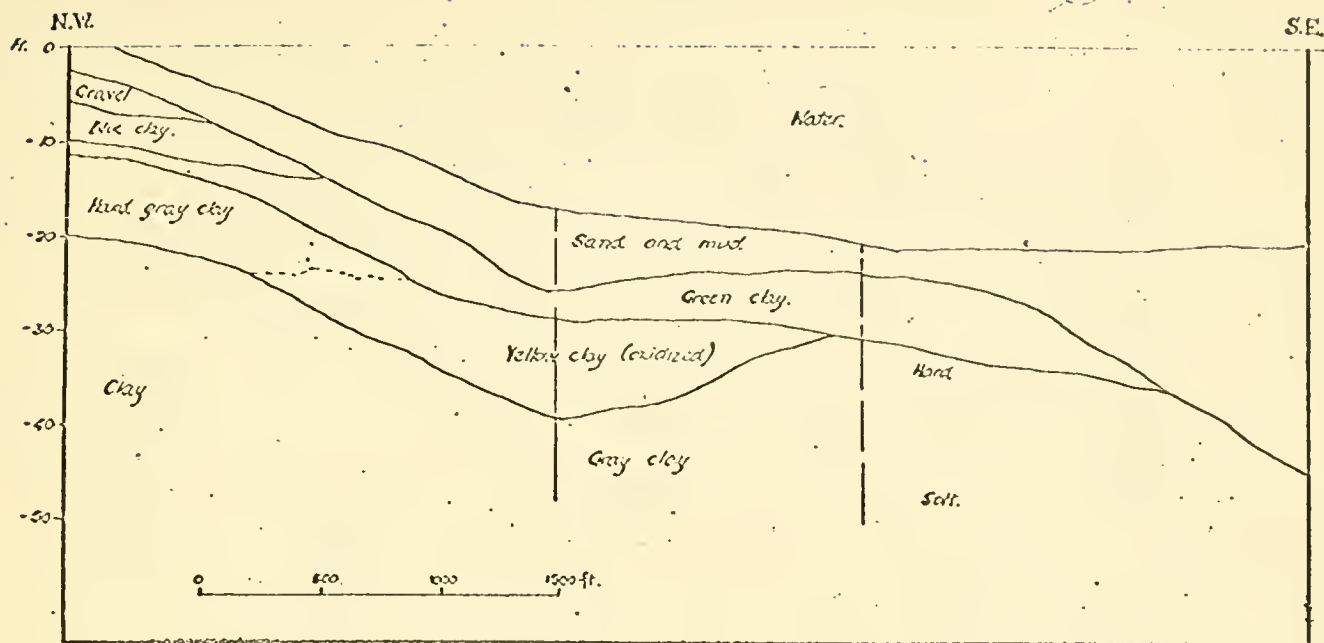


figure 4e. Section extending southeastwards from Castle Island.
(after Phipps, 1964)

III BOTTOM CONTOURS, WATER DEPTHS, AND TIDES

The upper surface of the Boston Blue Clay is highly irregular, showing a relief of over 100 feet within the harbor. The area around Thompson Island is somewhat less contorted, with broad tidal flats to the east and south, and shallow water to the southwest of the island. There is a deep channel to the west and northwest (from the Neponset River) and a valley between Thompson Island and Spectacle Island. (See figure 5.) There is direct evidence on Thompson Island (water marks on pilings) of at least 8 feet variation in water elevation. The U. S. G. S. map of Boston Harbor (USGS Map #246) indicates an average tide of about 9 feet throughout much of the harbor.

A recent report from the Downtown Waterfront Corporation (Metcalf and Eddy, 1963) indicates the highest recorded tide in Boston reached an elevation of 15.8 feet (datum equals Boston City Base, 0.8 feet below mean low water). This tide was caused by the combined effect of a strong onshore storm wind and a normally occurring high tide. Metcalf and Eddy concluded that a waterfront elevation of 17.0 feet BCB would allow ample clearance for high water plus allow for the rising level of the sea. However, it should be pointed out that a wave approaching a sloping beach front may run up the beach to an elevation considerably higher than that of the approaching wave. The amount of run up is very dependent upon local topography and is best determined empirically rather than predicted. The normal wave heights observed in the harbor seldom exceed about 2 feet. Larger waves, should they occur, can be reduced with breakwaters.

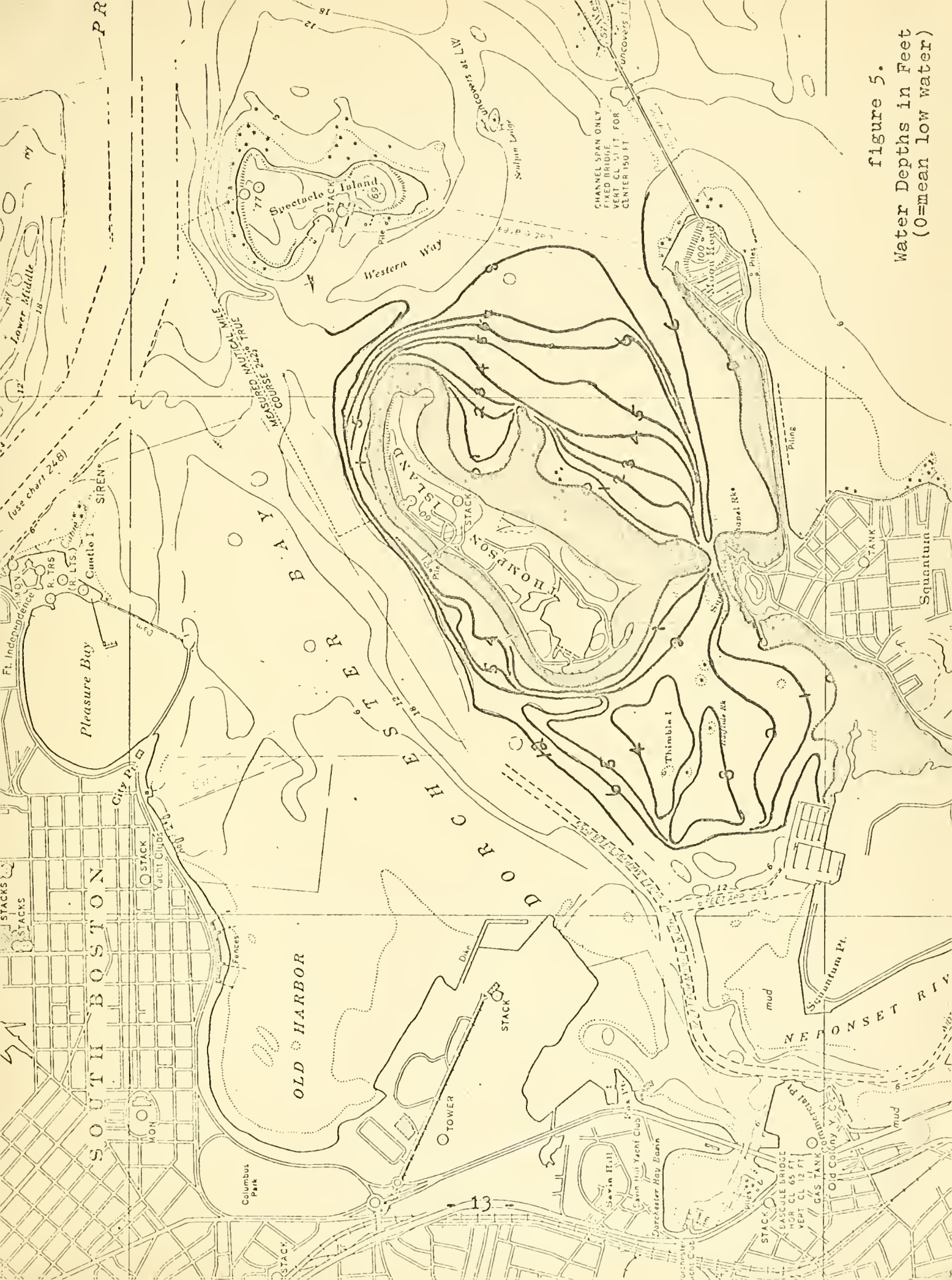


figure 5.

We question the the allowance of only 1.2 feet to provide additional clearance for the rising sea level. The current rate of subsidence of the harbor is about 0.02 feet per year. At this rate, the entire safety factor of 1.2 feet would be completely depleted within 70 years. For a project of this magnitude, 70 years hardly seems like long range planning.

IV FILL MATERIALS, PROCEDURES, AND COSTS; LOCATION OF BORROW AREAS

The exact type of material needed for a particular land fill area depends upon the use to which the new land is to be put. In an area which is to support high rise apartments with massive utilities services, small amounts of settling in the land fill can be disastrous — particularly if the settling is non-uniform. However, in areas designated for playgrounds or one story dwellings, the expected load upon the filled land is much smaller, and settling would not be expected to have such a serious effect.

Generally, coarse granular materials such as clean sand and gravel are much less compressable than materials such as soft clay, silt, mud, etc., and are less likely to give way to settling than are the latter materials. Thus, Boston Blue Clay would be adequate fill material for a projected playground, but not for an industrial complex.

Another source of potential settling is the condition of the base material and subsoil upon which fill is to be placed. An area containing thick beds of soft clay and mud over a deep bedrock layer will settle much more than an area containing sand and gravel beds over shallow bedrock. Soft black mud is particularly undesirable as a surface deposit since it may be displaced by the weight of the fill material. In general, it is advisable to remove thick mud deposits before placing the fill.

For the purpose of filling land in a water environment

it is usually less expensive to hydraulically pump or even barge the fill material from another water environment than to transport the material over land. However, it is not always possible to find adequate amounts of fill material near the area to be filled. In general, there is an abundant supply of clay located within the harbor, and it may be placed at a cost little more than the cost of dredging the bottom. However, there seem to be no extensive sand or gravel borrows within the harbor area. Mr. Carl Hard of the U. S. Army Corps of Engineers disclosed to us that in his surveys of the New England coastline for granular material to be used in enriching local beaches, he found no large sand or gravel deposits closer than Cape Ann to the north or Plymouth to the south. He added that there are closer borrow areas, but they probably do not contain enough material for our purposes (we estimated 10 million + cubic yards of fill), and they are very likely to be depleted in the near future. (See figure 6.)

Hydraulic transport of granular material over extreme distances can become difficult and costly. Mr. Hard suggested that we hydraulically dredge the fill material into barges, transport the barges to an area near the site, dump the fill, and finally pump the fill into place. He added that we might avoid the cost of dredging the surface mud from the fill area by pumping the fill (granular only) onto Thompson Island and then pushing it into place with bulldozers, displacing the mud as the fill is placed.

This displacement technique was discussed with the engineering firms of Haley and Aldrich; and Hayden, Harder, and

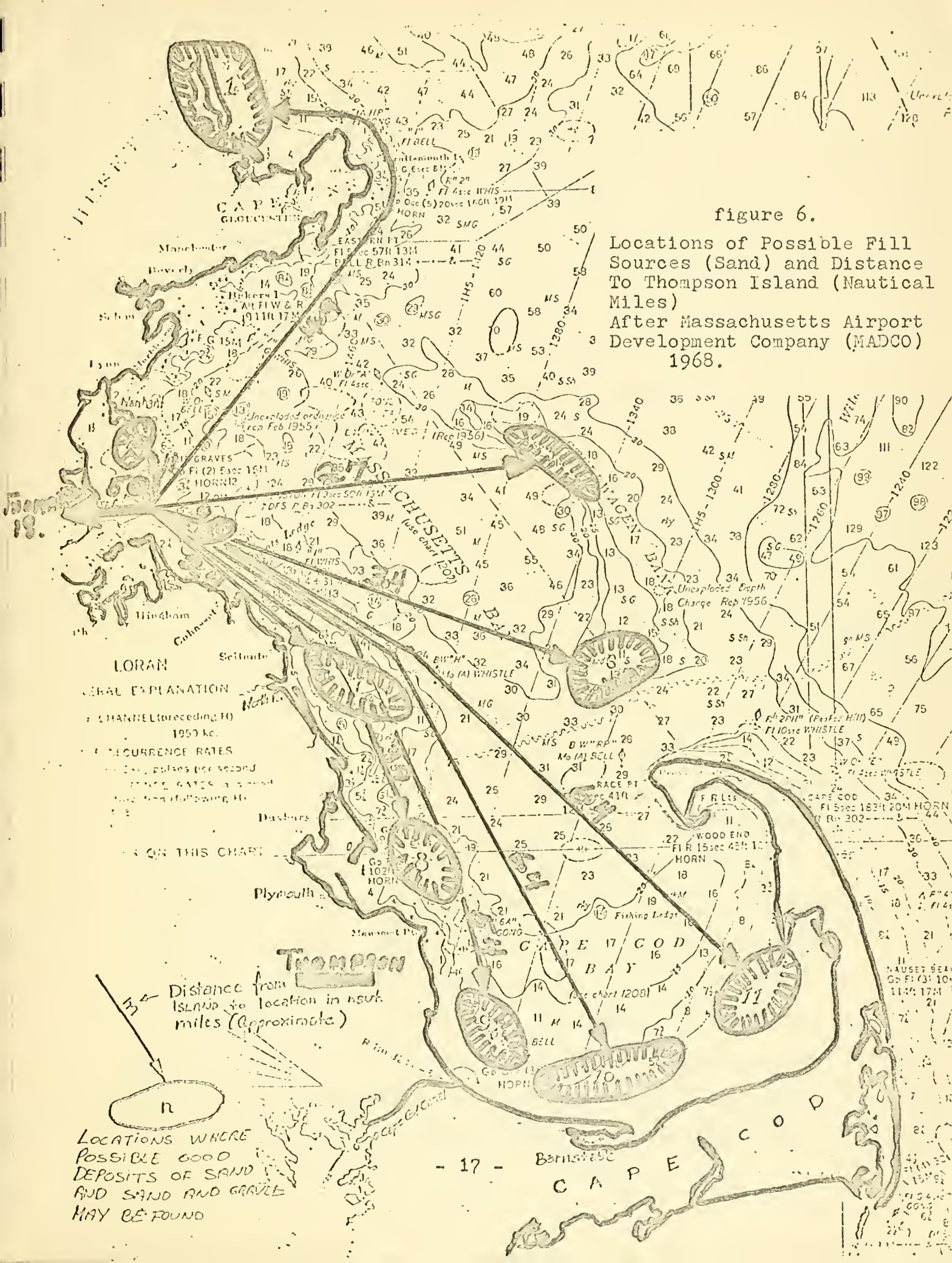


figure 6.

Locations of Possible Fill Sources (Sand) and Distance To Thompson Island (Nautical Miles) After Massachusetts Airport Development Company (MADCO) 1968.

GENERAL EXPLANATION

- CHANNEL (preceding H) 1957 Kc.
- RECURRENCE RATES
- 2nd, pulses per second
- 3rd, GATES 3rd
- 4th, 1st following H

ON THIS CHART

Distance from Island to location in naut. miles (Approximate.)

LOCATIONS WHERE POSSIBLE GOOD DEPOSITS OF SAND AND SAND AND GRAVEL MAY BE FOUND

Buchanan. Both firms felt there was considerable danger of trapping pockets of mud which could ultimately result in severe local settling. Thus, while this technique is adequate for such purposes as highway construction, it would not provide adequate support for an urban complex. Hayden, Harder, and Buchanan recommended dredging the mud (the problem of where to dispose of the mud remains to be solved) and dumping barged fill directly into place. They quoted a figure of "...\$2.00 to \$3.00 per cubic yard...probably closer to \$3.00..." to obtain, transport, and place the fill.

Mr. Kaye of the U. S. G. S. pointed out that perhaps some of the material from the gravel outwash located on and around the southern part of the island might be utilized as fill. While there is record of this gravel layer in the handbook prepared by the Boston Society of Civil Engineers (1961), it is not known how extensive this gravel bed is, or how much gravel is contained therein. When questioned as to the feasibility of using this gravel, Hayden, Harder, and Buchanan commented that if the gravel were clean, the overlying mud might be dredged off and the gravel pumped into place at a cost considerably less than that of barging fill from Cape Cod. They added that the final figure would be closer to \$2.00 per cubic yard for fill of this type.

Figure 7 gives a very rough estimate of the cost per square foot of filled land contoured around Thompson Island. These costs are based upon 1) barged granular fill costing \$3.00 per cubic yard, in place; 2) estimated average depth

Can they be translated into high-rise/low
rise foundation costs?

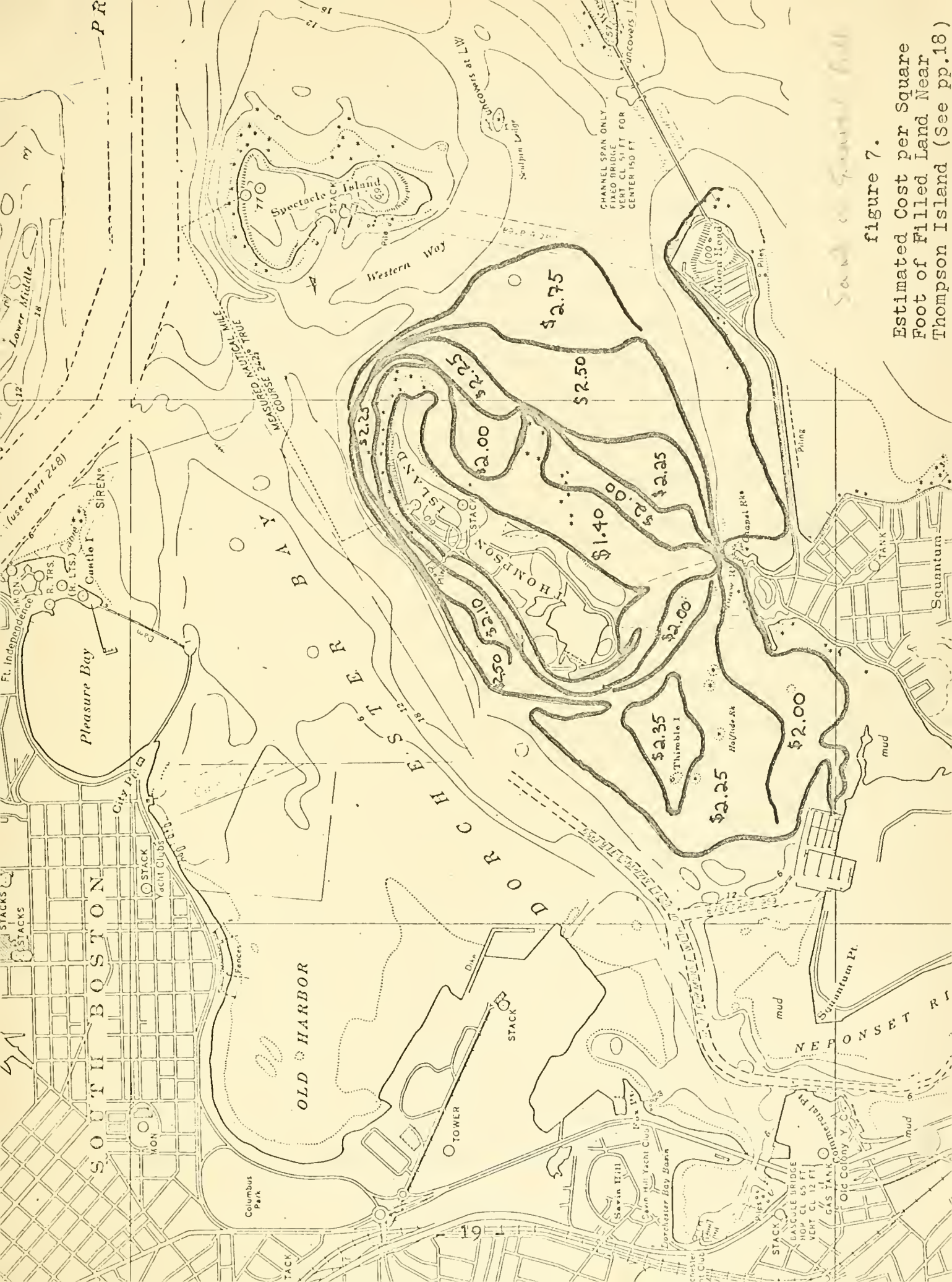


figure 7.

Estimated Cost per Square Foot of Filled Land Near Thompson Island (See pp.18)

of 5 feet of mud to be dredged from fill site at \$0.60 per cubic yard; 3) fill to elevation +17.0 feet BCB. These amounts do not allow for compaction of the fill or subsoil, nor do they include costs of dyking or free standing slope of the fill beyond the contours shown. In the area near the channel to the northwest of the island and the valley northeast of the island some dyking would be absolutely necessary to prevent the fill material from slumping into the deeper water. In the mud flats to the east and southwest the fill material might be placed on a free standing slope (1 to 1 for sand; 20 to 1 for hydraulic clay). Alternatively, dykes could be placed to hold the fill here also.

Since the amount of dyking or sloping fill needed depends upon the length of the perimeter of the fill area and the water depth at the perimeter, it is impossible to give accurate costs until this perimeter has been established. Also, the amount of sediment (subsoil) compaction depends upon the type and thickness of the subsoil, and no accurate settlement predictions can be made without prior geophysical surveys.

Both settlement and dyking (or allowance for sloping fill) will ultimately increase the cost per square foot of filled land. It should be pointed out, however, that the figure of \$3.00 per cubic yard of fill was obtained as a rough estimate from one engineering firm. The recent student airport studies at M. I. T. (Massachusetts Airport Development Company, 1968) arrived at a final cost of \$2.00 per cubic yard for barged fill (sand) to the Brewster Islands, 4 nautical miles from Thompson Island. Weston

Geophysical Engineers, Inc. concurred that \$3.00 seemed higher than other quotes for similar construction projects, and that \$2.00 per cubic yard seemed more reasonable. They added, however, that they were not in the business of land filling. Obviously, more information is needed. It is hoped, however, that the suggested lower cost of fill material will at least offset the cost of dykes (or slopes) and settling allowances.

Naturally, the cost of placing hydraulic clay would be much lower than that of sand and gravel. \$1.00 per cubic yard was felt to be a reasonable upper bound on the cost of clay fill. (See figure 8.)

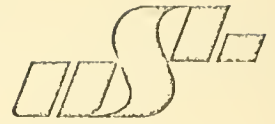
V RESTRICTIONS ON LAND FILL AREAS

It is expected that any fill operation within the harbor will have some effect upon water circulation there. When asked specifically about water pollution, Mr. Hard of the Army Corps of Engineers stated that he did not expect any pollution problems to result from land fill around the harbor islands, provided we did not close off any waterways between the islands and the mainland. He suggested, however, that we consult the Department of Waterways when we had more specific plans for land fill areas. In addition, we expect some advice from other members of the M. I. T. faculty concerning the matter of pollution in the harbor.

Mr. Hard added that the Corps of Engineers was more concerned that we do not obstruct or interfere with the navigable channels within the harbor. He specifically advised us to stay clear of the "President Roads" area. Plans call for future widening and deepening of this channel. He also suggested that we respect the many channels used by private boats and pleasure craft.

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APPENDIX

Massachusetts Institute of Technology

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Tel. 617-864-6900

July 30, 1968

Reply to Professor Fred Moavenzadeh

Room 1-171

Mr. Charles Hilgenhurst
Director of Urban Design
Boston Redevelopment Authority
City Hall Annex
Boston, Massachusetts

Dear Mr. Hilgenhurst:

In order to have a better understanding of the geologic and soil conditions in the vicinity of Columbia point and Thompson Island, Messrs. David Hughes and Richard Edmunds of our group met with Messrs. D. Holt and V. Murphy of Weston Geophysical Engineers, Inc., to discuss costs and scheduling of seismic surveys for the area surrounding Thompson Island, in Dorchester Bay. It was agreed that seismic profiles on the perimeter of the island and the [-6] foot elevation contour (referred to mean low water) would adequately define the area of interest, and that profiles spaced every 500' in the mud flats to the southeast would give extensive coverage of that area. (See Figure 1). Weston Geophysical Engineers' rough estimate of costs is:

- 1) \$1,000 preliminary surveying to accurately locate the profiles.
- 2) \$10,000 actual seismic profiles and interpretations.
- 3) \$3,000 for boat rental (required for offshore profiles).

Thus a conservative estimate of \$14,000 to \$15,000 total for the job was obtained. Mr. Holt stressed that this could vary somewhat depending upon the exact bottom configurations.

For 1000' separation of profiles in the mud flats instead of 500' (Delete dashed line in Figure 1), the total cost was estimated at \$11,000 to \$12,000.

Mr. Holt commented that under their present workload they could begin work about two weeks after receiving a definite commitment. The total time from beginning to final report should be about one month, though data and preliminary information could be presented on a day-by-day basis as it is received. The information to be received from this type of survey includes depth to bedrock and depth and thickness of clay and unconsolidated deposits. As we have previously agreed, this information is vital in determining the type of foundations

which are necessary for a building project in this area, the feasibility of driving piles, and the expected settling of filled land.

As noted in figure 2, we already have some definite information concerning depth to bedrock in the Columbia Point Area. The Boston Boring Log gives a fairly extensive account of the sedimentary deposits to be expected in this region. In addition, Boston Edison has extensive seismic information in the Squantum Point area and throughout much of the Neponset River Estuary. I believe Weston Geophysical has done this work, but they are bound by Edison not to divulge their findings. However, perhaps Edison would allow this material to be released to the BRA.

It is essential that information of the type discussed with Weston Geophysical be obtained before reliable engineering work can be done relating to cost and type of fill, foundations, and utilities placement. In view of the magnitude and time schedule for the BRA project, the original proposal for 500 foot spacing of profiles in the mudflats would seem advantageous. This would give more resolution than 1000 foot spacing, and would avoid more expensive and time consuming resurveying of the area, should this information become crucial at a later date. The additional expenditure (\$14,000 to \$15,000 versus \$11,000 to \$12,000) seems justifiable at this time.

Please let me know if your office is interested in conducting this survey in the future. We will be very glad to contact Weston Geophysical Engineers for more accurate cost and job definitions.

Sincerely yours,

Fred

Fred Moavenzadeh
Associate Professor
Department of Civil Engineering

cc
FM:cw

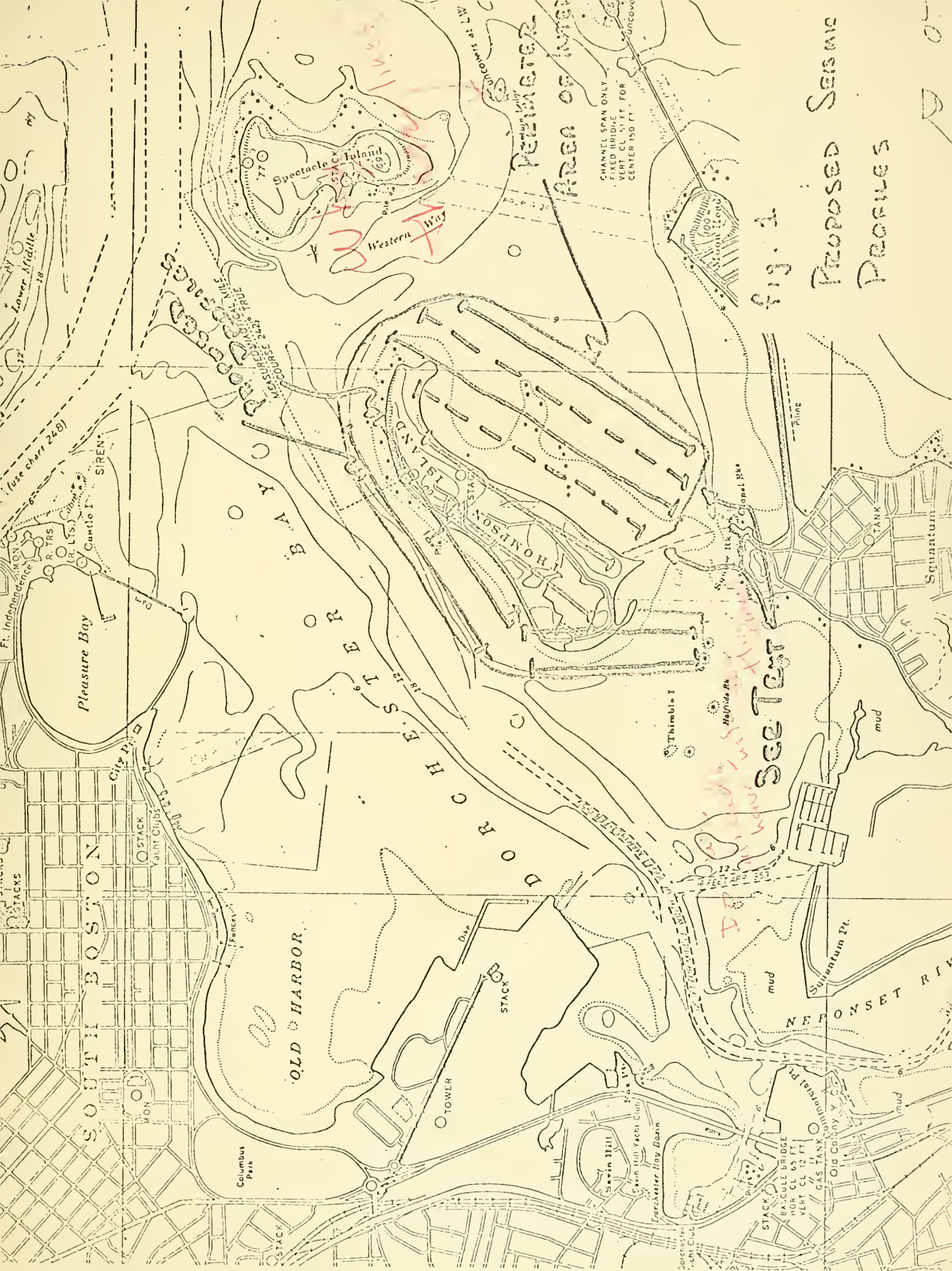


fig. 1

Proposed Seismic Profiles



fig. 2

DEPTH TO
BEDROCK PROFILES
- Dorchester Bay -

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